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Technical Report to ONR

1996 Spring MRS Meeting, Symposium B: Defects and Interfaces in Lattice-Mismatched Semiconductor Heterostructures

Symposium Chair: P.M. Mooney (IBM)

Co-Chairs: K.L. Kavanagh (UCSD), L.J. Brillson (Xerox) and B.W. Wessels (NWestern U.)

Symposium B - Defects and Interfaces in Lattice-Mismatched Heterstructures, was considered a great success by all concerned. It filled 3 days and was well attended by approximately 100 attendees/day. We invited 12 speakers from a range of expertise which helped to attract 97 abstracts, 22 of which were rejected, 32 designated as posters and 43 talks. The symposium emphasized problems common to every semiconductor heterstructure with the aim of bringing together scientists working on different lattice-mismatched semiconductor systems. Thus, the session titles, listed below, reflected this approach as much as possible.

Session B1: Interface Roughening and Interdiffusion in Heterostructures

Session B2: Properties of Dislocations and Effects of Substrate Miscut

Session B3: Strain Relaxation in Heterstructures

Session B4: Strain Relaxation/Dislocations in SiGe (Jointly with Symp F - GeSi and Related Compounds)

Session B5: Poster Session

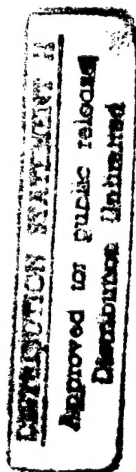
Session B6: Defects in Quantum Structures

Session B7: Defects in ZnSe-Based Heterostructures

We were able to obtain MRS corporate sponsorship for our symposium totaling \$5000. Adding the \$2000 support from ONR brought our total budget to \$7000. This was consumed by registration fees and travel support of the invited speakers, symposium organisers and session chairs as detailed in the attached budget summary.

Highlights of the Sessions

Applications of lattice-mismatched semiconductor heterostructures for state-of-the-art electronic and optoelectronic devices discussed in this symposium included blue-green lasers fabricated from II-VI semiconductors, various quantum structures fabricated with III-V semiconductors, and high-speed field effect transistors (FETs) utilizing strained Si or SiGe layers on relaxed SiGe buffer layers. Although the dislocations threading through the SiGe buffer layers are electrically active, concentrations are low enough that their effects on low temperature electron mobility are negligible. New results on the fundamental properties of dislocations include the real time observation of the motion of dislocation kinks in plastically deformed Si by high resolution transmission electron microscopy and the observation by spatially resolved electron energy loss spectroscopy of changes in the electronic structure of the heterojunction in the vicinity of a misfit dislocation near the interface between a strained Si layer on relaxed SiGe. Calculations of the modification of the surface morphology of



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SiGe films due to mismatch strain and resulting compositional variations in the layer were also reported as were calculations of the strain redistribution both the SiGe film and the Si substrate.

Fundamental issues associated with strain relaxation mechanisms and interface roughness were addressed in many of the talks on III-V materials. The usefulness of high resolution x-ray diffraction techniques including both topography and reciprocal space mapping for evaluating the quality of epitaxial layers and for the study of strain relieving defects was demonstrated. In-situ x-ray topography was carried out during molecular beam epitaxy growth of InGaAs/GaAs heterostructures at a synchrotron source. By correlating the x-ray images with localized transmission electron microscopy images the nature of the misfit dislocation sources at the interface as a function of epilayer thickness was determined. Linearly polarized cathodoluminescence imaging was applied to the study of III-V semiconductor heterostructures. Local variations in excitonic polarization anisotropy, emission energy and activation energy are found to correlate spatially with dark-line defects in the material. Investigations of interface uniformity using cross-sectional STM was described.

A dramatic improvement in the defect density of ZnSe-based heteroepitaxial structures for blue-green laser diodes was announced. Employing a combination of homoepitaxial buffer layers, improved pregrowth wafer handling, Zn irradiation, and migration enhanced epitaxy on c(4x4) ordered GaAs surfaces, the an etch pit density of $1-3 \times 10^3 \text{ cm}^{-2}$ over a 3" wafer was achieved. Such defect density reductions are closely tied to improvements in expected laser diode lifetimes. Dramatic improvements in ZnCdSe epilayers on InP were also achieved by optimizing initial growth and substrate preparation procedures. A mechanism for the degradation of ZnSe-based heteroepitaxial diode laser structures based on the emission of a cluster of vacancies from Frank-type stacking faults, leading to strain generation of small dislocation loops and the formation of dark line defects was proposed.

1996 SPRING MEETING

BUDGET SUMMARY

SYMPOSIUM B

[Karen Kavanagh]

SPONSORS:

Office of Naval Research	2000.00
Charles Evans and Associates	500.00
Xerox Wilson Center	1500.00
IBM Analytical Services	1000.00
Blake Industries Inc.	500.00
Philips Electronic Instruments	1000.00
Bede Scientific	500.00
Total	7000.00

ATTENDEES	REGS	PROC	TRAVEL	OFFICE	A/V	FOOD	TOTAL
P.E. Batson	345.00						345.00
I. Bassignana	345.00						345.00
L. Brillson	295.00						295.00
A. Cullis	295.00		500.00				795.00
Rachel Goldman			100.00				100.00
R. Gunshor	0.00						0.00
Derek Houghton			100.00				100.00
K. Ismail	345.00		500.00				845.00
K. Kavanagh	295.00		181.52	127.84			604.36
P. Mooney	295.00		181.52				476.52
D. Rich	295.00		200.00				495.00
Salamanca-Riba	295.00						295.00
G. Salvati			100.00				100.00
J. Spence	295.00						295.00
H.P. Strunk	295.00		500.00				795.00
Tom Tiedje			100.00				100.00
P.W. Voorhees	295.00						295.00
B. Wessels	0.00		295.00				295.00
Ed Yu	295.00						295.00
							0.00
4/8: VCR					129.12		129.12
TOTAL	3985.00	0.00	2758.04	127.84	129.12	0.00	7000.00
BALANCE							0.00

Prepared By: Donna Gillespie

Date Prepared: 1/4/96 3/6/96 3/11/96 3/12/95 4/2/96

DRAFT FINAL: 5/14/96

ACCOUNT CLOSED: 6/7/96

ONR: 5 copies of a Technical Report for ONR due to MRS Hqs.

SYMPOSIUM B

DEFECTS AND INTERFACES IN LATTICE-MISMATCHED SEMICONDUCTOR HETEROSTRUCTURES

April 8 - 10, 1996

Chairs

Patricia M. Mooney
IBM T.J. Watson Research Center

Karen L. Kavanagh
University of California, San Diego

Leonard J. Brillson
Xerox Wilson Center for Research and Technology

Bruce W. Wessels
Northwestern University

Symposium Support

Bede Scientific, Inc.
Blake Industries, Inc.
Charles Evans and Associates
IBM Analytical Services
Philips Electronic Instruments Co.
Xerox Wilson Center for Research and Technology
Office of Naval Research

*Invited Paper

SESSION B1: INTERFACE ROUGHENING AND INTERDIFFUSION IN HETEROSTRUCTURES

Chairs: K.L. Kavanagh and T. Tiedje
Monday Morning, April 8
Sunset E

8:30 A.M. ***B1.1**
THE STABILITY OF HETEROEPITAXIAL THIN FILMS, J.E. Guyer, H. Wong, S. Davis, M.J. Miksis and P.W. Voorhees, Northwestern University, Department of Materials Science and Engineering, Evanston, IL.

9:00 A.M. ***B1.2**
MECHANISMS OF PLASTIC RELAXATION IN HETEROEPITAXIAL SEMICONDUCTOR GROWTH, Horst P. Strunk, Martin Albrecht, Silke Christiansen and Johannes Michler, Institut fuer Werkstoffwissenschaften, Lehrstuhl Mikrocharakterisierung, Erlangen, Germany.

9:30 A.M. **B1.3**
STABILITY MAPS FOR STRAINED LAYER EPITAXY: KINETIC MODELS AND EXPERIMENTAL DATA FROM MBE AND UHVCD OF Si_{1-x}Ge_x/(001)Si, D.C. Houghton, H. Lafontaine, J.-M. Baribeau, Institute for Microstructural Sciences, National Research Council of Canada, Ottawa, Canada; B. Bahierathan and D.D. Perovic, University of Toronto, Toronto, Canada.

9:45 A.M. **B1.4**
KINETIC PATHWAYS TO STRAIN RELAXATION IN THE Si-Ge SYSTEM, D.E. Jesson, K.M. Chen, S.J. Pennycook, Oak Ridge National Laboratory, Solid State Division, Oak Ridge, TN; T. Thundat and R.J. Warmack, Oak Ridge National Laboratory, Health Science Research Division, Oak Ridge, TN.

10:00 A.M. BREAK

10:30 A.M. ***B1.5**
CROSS-SECTIONAL SCANNING TUNNELING MICROSCOPY OF ARSENIDE/ANTIMONIDE AND ARSENIDE/PHOSPHIDE SEMICONDUCTOR HETEROSTRUCTURES, E.T. Yu, A.Y. Lew, R.B. Welstand, C.H. Yan, J.T. Zhu, C.W. Tu, P.K.L. Yu, University of California, Department of Electrical and Computer Engineering, La Jolla, CA; D.H. Chow, R.H. Miles and Y.H. Zhang, Hughes Research Laboratories, Malibu, CA.

11:00 A.M. **B1.6**
ATOMIC SCALE DIFFUSION PROCESSES AND RELIABILITY OF LOW-TEMPERATURE-GaAs BASED DEVICES, Christian Kisielowski, University of California, Materials Science Department, Berkeley, CA; Hyunchul Sohn and Zuzanna Liliental-Weber, Lawrence Berkeley Laboratory, Materials Science Division, Berkeley, CA.

11:15 A.M. **B1.7**
STRUCTURE AND STABILITY OF DEFECTS IN AN In_{0.53}Ga_{0.47}As/GaAs(001) HETEROSTRUCTURE: A THEORETICAL STUDY, Amore Bonapasta Aldo, Istituto di Chimica dei Materiali, Consiglio Nazionale delle Ricerche, Monterotondo, Italy.

11:30 A.M. **B1.8**
CdTe/Si STUDIED BY PHOTOELECTRON SPECTROSCOPY, R. Sporken, F. Malengreau, J. Ghijssels, R. Caudano, Facultés Universitaires Notre-Dame de la Paix, LISE, Namur, Belgium; S. Sivananthan, J.P. Faurie, University of Illinois at Chicago, Chicago, IL; T. Buslaps, T. Von Gemmeren and R.L. Johnson, Universität Hamburg, Hamburg, Germany.

11:45 A.M. **B1.9**
DEFECTS IN HIGHLY In-DOPED MOCVD GROWN CdTe ON GaAs, T. Filz, J. Hamann, V. Ostheimer, H. Wolf and Th. Wichert, Universität des Saarlandes, Technische Physik, Saarbrücken, Germany.

SESSION B2: PROPERTIES OF DISLOCATIONS AND EFFECTS OF SUBSTRATE MISCUT

Chairs: R. Hull and H. Strunk
Monday Afternoon, April 8
Sunset E

1:30 P.M. ***B2.1**
DIRECT OBSERVATIONS OF DISLOCATION KINKS BY TEM/AB-INITIO CALCULATIONS OF KINK ENERGIES, John C. Spence, H. Kolar and Y. Huang, Arizona State University, Department of Physics, Tempe, AZ.

2:00 P.M. ***B2.2**
SPATIALLY RESOLVED ELECTRONIC STRUCTURE OF SILICON QUANTUM WELLS IN THE PRESENCE OF MISFIT DISLOCATION STRUCTURES, P.E. Batson, IBM Thomas J. Watson Research Center, Yorktown Heights, NY.

2:30 P.M. **B2.3**
MISFIT DISLOCATION INTERACTIONS OBSERVED IN InGaAs ON OFF-CUT, PATTERNED GaAs BY CATHODOLUMINESCENCE, G.P. Watson, AT&T Bell Laboratories, Murray Hill, NJ; and D.G. Ast, Cornell University, Materials Science and Engineering Department, Ithaca, NY.

2:45 P.M. **B2.4**
STRUCTURAL AND OPTICAL STUDY OF InGaAs BUFFER LAYERS COMPOSITIONALLY GRADED WITH DIFFERENT LAWS, A. Bosacchi, A.C. DeRiccardis, C. Ferrari, S. Franchi, L. Lazzarini, G. Salvati, MASPEC-CNR Institute, Parma, Italy; A.V. Drigo and F. Romanato, University of Padova, INFN, Physics Department, Padova, Italy.

3:00 P.M. BREAK

3:30 P.M. **B2.5**
EFFECTS OF GaAs SUBSTRATE MISORIENTATION ON PROPERTIES OF InGaAs/InAlAs HETEROSTRUCTURES, R.S. Goldman, Carnegie Mellon University, Department of Physics, Pittsburgh, PA; K.L. Kavanagh, H.H. Wieder, University of California, San Diego, Department of Electrical and Computer Engineering, La Jolla, CA; S.N. Ehrlich, Purdue University, School of Materials Engineering, West Lafayette, IN; R.M. Feenstra, Carnegie Mellon University, Department of Physics, Pittsburgh, PA.

3:45 P.M. **B2.6**
STRAIN RELAXATION AND DEFECT GENERATION IN ZnSe/GaAs (001) GROWN BY LOW-PRESSURE OMVPE, Sergei Ruvimov, Zuzanna Liliental-Weber, Edith D. Bourret, X.-W. Lin, Young Chen and Jack Washburn, Lawrence Berkeley National Laboratory, Berkeley, CA.

4:00 P.M. **B2.7**
THE POSSIBILITY OF GaAs SUBSTRATES WITH ULTRA-LAW THREADING DISLOCATION DENSITIES, Glyn MacPherson and P.J. Goodhew, University of Liverpool, Department of Materials Science and Engineering, Liverpool, United Kingdom.

4:15 P.M. **B2.8**
HETEROEPITAXY OF STRAINED-LAYER InAsSb, S.C. Theiring and B.W. Wessels, Northwestern University, Department of Materials Science and Engineering, Evanston, IL.

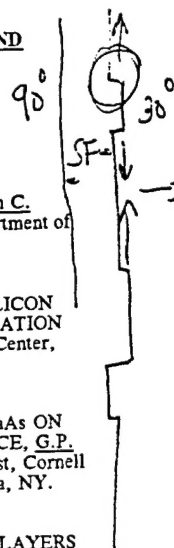
4:30 P.M. **B2.9**
STUDY OF STRAIN RELAXATION IN LARGE MISMATCHED CdTe EPITAXY GROWN ON (211) Si BY MOLECULAR BEAM EPITAXY, H.Y. Wei, L. Salamanca-Riba, University of Maryland, Department of Materials and Nuclear Engineering, College Park, MD; N.K. Dhar, US Army Research Laboratory, Fort Belvoir, VA.

4:45 P.M. **B2.10**
THE EFFECT OF SUBSTRATE MISORIENTATION ON STRAIN RELAXATION MECHANISMS IN EPITAXIALLY GROWN CaF₂/Si(111) HETEROSTRUCTURES, B.M. Kim, S.R. Soss, L.J. Schowalter, Rensselaer Polytechnic Institute, Physics Department and Center for Integrated Electronics and Electronics Manufacturing, Troy, NY; and Thomas G. Thundat, Oak Ridge National Laboratory, Oak Ridge, TN.

SESSION B3: STRAIN RELAXATION IN HETEROSTRUCTURES

Chairs: P.M. Mooney and G. Salvati
Tuesday Morning, April 9
Sunset E

8:30 A.M. ***B3.1**
THE KEY ROLE OF X-RAY DIFFRACTION ANALYSIS IN THE DEVELOPMENT OF STRAINED LAYER DEVICES, I.C. Bassignana,



Bell-Northern Research Ltd., Advanced Technology Laboratory, Ottawa, Canada; M.A.G. Halliwell, Trimley St. Mary, Ipswich, United Kingdom; and D.A. Macquistan, Bell-Northern Research Ltd., Advanced Technology Laboratory, Ottawa, Canada.

9:00 A.M. **B3.2**
HIGH-RESOLUTION RECIPROCAL SPACE MAPPING AND ANALYSIS OF InGaAs/GaAs STEP-GRADED LAYERS, Patricia Kidd, University of Surrey, Department of Materials Science and Engineering, Guildford, United Kingdom; P.F. Fewster, N.L. Andrew, Philips Research Laboratory, Redhill, United Kingdom; L. Gonzalez and Y. Gonzalez, Centro Nacional de Micoelectrónica, Madrid, Spain.

9:15 A.M. **B3.3**
X-RAY DIFFRACTION STUDY OF THE INTERFACE MORPHOLOGY IN HIGH TEMPERATURE GROWN $\text{Si}_{1-x}\text{Ge}_x/\text{Si}$ SUPERLATTICES, J.-M. Baribeau, Institute for Microstructural Sciences, National Research Council Canada, Ottawa, Canada.

9:30 A.M. **B3.4**
WAFFER MAPPING USING TRIPLE AXIS X-RAY DIFFRACTION: CORRELATION OF SUBSTRATE PERFECTION TO EPILAYER QUALITY OF HIGH ELECTRON MOBILITY TRANSISTORS, Mariohn Meshkinpour, Kevin Matney, Mark Goorsky, University of California, Los Angeles, Department of Materials Science and Engineering, Los Angeles, CA; Dwight Streit, Tom Block and Mike Wojtowicz, Rf Products Center, Redondo Beach, CA.

9:45 A.M. BREAK

10:15 A.M. **B3.5**
THREADING DISLOCATIONS AND THEIR DISTRIBUTION IN MOVPE-GROWN CdTe/GaAs EPILAYERS, Ken Durose, Ruth I. Port and Brian K. Tanner, University of Durham, Department of Physics, Durham, United Kingdom.

10:30 A.M. **B3.6**
STRUCTURAL AND ELECTRONIC PROPERTIES OF GAN FILMS GROWN ON SAPPHIRE BY MOLECULAR BEAM EPITAXY, Q. Zhu, Brookhaven National Laboratory, Physics Department, Upton, NY; A. Botchkarev, W. Kim, O. Aktas, A. Salvador, B. Sverdlov, H. Morkoc, University of Illinois at Urbana-Champaign, Urbana, IL; S.-C.Y. Tsen and D.J. Smith, Arizona State University, Department of Physics and Astronomy and Center for Solid State Science, Tempe, AZ.

10:45 A.M. ***B3.7**
IN SITU SYNCHROTRON X-RAY STUDIES OF MISFIT DISLOCATION BEHAVIOUR IN MBE InGaAs/GaAs, A.G. Cullis, C.R. Whitehouse, Sheffield University, Department of Electronic and Electrical Engineering, Sheffield, United Kingdom; A.M. Keir, A.D. Johnson, T. Martin, S.J. Carnett, DRA Malven, Worca, United Kingdom; B. Lunn, G. Lacey, G.F. Clark, DRAL Daresbury Laboratory, Daresbury, United Kingdom; and B.K. Tanner, Durham University, Department of Physics, Dunham, United Kingdom.

11:15 A.M. **B3.8**
A THEORY FOR THE REDUCTION OF THREADING DISLOCATION DENSITIES IN LATTICE-MISMATCHED HETEROEPITAXY, J.S. Speck, Glenn E. Beltz, University of California, Department of Mechanical and Environmental Engineering, Santa Barbara, CA; A.E. Romanov, A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russia; and W. Pompe, Technical University of Dresden, Dresden, Germany.

11:30 A.M. **B3.9**
CRACKING AND EXFOLIATION IN EPILAYERS SUFFERING TENSILE STRAIN, Robert Murry, Christopher Kiely, University of Liverpool, Department of Materials Science, Liverpool, United Kingdom; and Mark Hopkinson, University of Sheffield, Department of Electrical Engineering, Sheffield, United Kingdom.

11:45 A.M. **B3.10**
STRAIN RELAXATION AND DEFECTS INTRODUCTION: COMPARISON BETWEEN MISMATCHED SYSTEMS PRESENTING TENSILE AND COMPRESSIVE STRESS, M.R. Bruni, G. Padeletti, M.G. Simeone, ICMAT-CNR Institute, Parma, Italy; L. Francesio, P. Franzosi, L. Nasi, G. Salvati, MASPEC-CNR Institute, Prama, Italy.

SESSION B4/F2: STRAIN RELAXATION/DISLOCATIONS IN GeSi

Chair: D.W. Greve
Tuesday Afternoon, April 9
Sunset E

1:30 P.M. ***B4.1/F2.1**
RELAXED GeSi/Si: MATERIAL LIMITS, DETECTORS AND TEMPLATES, E.A. Fitzgerald, Massachusetts Institute of Technology, Department of Materials Science and Engineering, Cambridge, MA.

2:00 P.M. ***B4.2/F2.2**
CORRELATION BETWEEN DISLOCATIONS AND ELECTRON TRANSPORT PROPERTIES IN Si/SiGe, K. Ismail, IBM T.J. Watson Research Center, Yorktown Heights, NY.

2:30 P.M. **B4.3/F2.3**
ELECTRICAL CONDUCTIVITY TYPE CONVERSION DUE TO STRAIN-RELAXATION RELATED DEFECTS IN GeSi/Si, P.N. Grillo, S.A. Ringel, Ohio State University, Electronic Materials and Devices Laboratory and Department of Electrical Engineering, Columbus, OH; E.A. Fitzgerald and J. Michel, Massachusetts Institute of Technology, Department of Materials Science and Engineering, Cambridge, MA.

2:45 P.M. **B4.4/F2.4**
ELECTRICALLY ACTIVE DISLOCATION-RELATED STATES IN RELAXED SiGe LAYERS, P.M. Mooney, L.P. Tilly, C.P. D'Emic and J.O. Chu, IBM T.J. Watson Research Center, Yorktown Heights, NY.

3:00 P.M. BREAK

3:30 P.M. **B4.5/F2.5**
INFLUENCE OF MISFIT DISLOCATION INTERACTIONS ON PHOTOLUMINESCENCE SPECTRA OF SiGe ON PATTERNED Si, G.P. Watson, J.L. Benton, Y.H. Xie, AT&T Bell Laboratories, Murray Hill, NJ; and E.A. Fitzgerald, Massachusetts Institute of Technology, Department of Materials Science and Engineering, Cambridge, MA.

3:45 P.M. **B4.6/F2.6**
ELECTRICAL ACTIVITY OF DISLOCATIONS IN SiGe/Si STRUCTURES, Martin Kitzler, Institute of Halbleiter Physik, Frankfurt, Germany; and Victor Higgs, Bio-Rad, Semiconductor Division, Hertfordshire, United Kingdom.

4:00 P.M. **B4.7/F2.7**
DISLOCATION NUCLEATION IN STRAINED LAYER EPITAXY: A BRITTLE-TO-DUCTILE PHENOMENON? Steven Labovitz, David Pope, Pennsylvania State University, Department of Materials Science and Engineering, Philadelphia, PA; and Ya-Hong Xie, AT&T Bell Laboratories, Silicon Materials, Murray Hill, NJ.

4:15 P.M. **B4.8/F2.8**
REAL TIME MEASUREMENTS OF ELASTIC AND PLASTIC STRAIN KINETICS DURING SiGe MBE GROWTH, J.A. Floro, E. Chason and S.R. Lee, Sandia National Laboratories, Albuquerque, NM.

4:30 P.M. **B4.9/F2.9**
SOI-BASED COMPLIANT SUBSTRATES-A NEW APPROACH TO HETEROEPITAXY, S.S. Iyer, SiBond L.L.C., Hopewell Junction, NY; F.J. Guarin, IBM Microelectronics Division, Hopewell Junction, NY; Z. Yang and W.I. Wang, Columbia University, Department of Electrical Engineering, NY.

SESSION B5: POSTER SESSION

Tuesday Evening, April 9
8:00 P.M.
Presidio Ballroom

B5.1 DEEP-LEVEL DEFECTS AT TITANIUM PLANAR-DOPED GaAs INTERFACES STUDIED BY CAPACITANCE SPECTROSCOPY, P. Krispin, Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany.

B5.2 OPTICAL STUDIES OF EXTREMELY HEAVILY DOPED STRAINED SI THIN FILMS, H. Yao, University of Nebraska, Department of Electrical Engineering, Lincoln, NE; H.-J. Gossmann, A.R. Kortan, T. Boone, AT&T Bell Laboratories, Murray Hill, NJ.

B5.3 UHV-HREM AND XPS ANALYSIS OF ROOM TEMPERATURE AU DEPOSITION ON Si(001)-2x1, Eric Landree, Daniel Grozea, Christopher Collazo-Davila and L.D. Marks, Northwestern University, Department of Materials Science and Engineering, Evanston, IL.

B5.4 OPTICAL PROPERTIES OF HEAT TREATED CRYSTALS OF ZnSe: I IN Se ATMOSPHERE, C. Uribe-Estrada and I. Hernández-Calderón, CINVESTAV, Physics Department, Mexico, Mexico; and R. Felipe, University of San Luis Potosi, Physics Department, San Luis Potosi, Mexico.

B5.5 ARSENIC PRECIPITATION BEHAVIOR IN InGaAs/GaAs SUPERLATTICES GROWN BY LOW TEMPERATURE MOLECULAR BEAM EPITAXY, Chan-Gvung Park, Chan Ho Park, Postech, Department of Materials Science and Engineering, Pohang, Korea; Sam-Kyu Noh, Hwack-Joo Lee and Chang Soo Kim, Kriss, Material Evaluation Center, Taejeon, Korea.

B5.6 NONLINEAR OPTICAL PROPERTIES OF (InP)/(GaP), BILAYER SUPERLATTICE STRUCTURES, Y. Tang, H.T. Lin, D.H. Rich, University of Southern California, Department of Materials Science and Engineering, Los Angeles, CA; P. Colter and S.M. Vernon, Spire Corporation, Bedford, MA.

B5.7 BEEM AND STM STUDIES OF SELF ASSEMBLED InAs ISLANDS, M.E. Rubin, E.Y. Lee, J.J. O'Shea, M.A. Chin, G. Medeiros-Ribeiro, P.M. Petroff, V. Narayanamurti, University of California, Department of Materials Science and Engineering, Santa Barbara, CA.

B5.8 PROPERTIES OF METASTABLE InGaAs/GaAs(100) QUANTUM DOTS (QDs) STRUCTURE GROWN BY MOLECULAR BEAM EPITAXY (MBE). Jeong-Hoon Yi, Cheol-Koo Han, In-Sang Jeon, Ju-Hee Lee, Moo-Sung Kim, Suk-Ki Min, Seong-Yoon Cho, Duk-Yeol Lee, In Hoon Choi and Jung-Ho Park, KIST, Semiconductor Materials Research Laboratory, Seoul, South Korea.

B5.9 ANALYSIS OF UNDULATION ON THE PATTERNED SUBSTRATE IN THE STRAINED LAYER MQW DISTRIBUTED FEEDBACK LASER DIODES. *Hyung Mun Kim, Jeong Soo Kim, Hye Rim Kim, Heung Ro Choo, Hong Man Kim and Kwang Eui Pyun, Electronics and Telecommunications Research Institute, Compound Semiconductor Department, Daejeon, Korea.*

B5.10 INTERFACE ROUGHNESS IN TILTED GaAs/InAs SUPERLATTICES. S.W. da Silva, Yu.A. Pusep, J.C. Galzerani, Universidade Federal de São Carlos, São Carlos, Brasil; D.I. Lubyshv, P.P. Gonzalez-Borrero, P. Basmaji, Universidade de São Paulo, Instituto de Física de São Carlos, São Carlos, Brasil; and A. Gutakovskii, Institute of Semiconductor Physics, Novosibirsk, Russia.

B5.11 MEASUREMENT OF INTERFACE FLATNESS WITH SECONDARY ION MASS SPECTROMETRY (SIMS). Jon W. Erickson, I. Ivanov, Charles Evans and Associates, Redwood City, CA; A.H. Bensaoula, A. Bensaoula, University of Houston, Space Vacuum Epitaxy Center, Houston, TX; and I. Rusakova, University of Houston, Texas Center for Superconductivity, Houston, TX.

B5.12 GaSb(100) SURFACE MORPHOLOGY: VARIATION WITH GROWTH TEMPERATURE. Stuart J. Brown, Michael P. Grimshaw, David A. Ritchie and Geraint A.C. Jones, University of Cambridge, Cavendish Laboratory, Cambridge, United Kingdom.

B5.13 EFFECT OF ANNEALING TEMPERATURE ON STRAIN IN GRAFTED InGaAs/GaAs FILMS ON PATTERNED Si SUBSTRATES. K. Rammohan, D.H. Rich, University of Southern California, Department of Materials Science and Engineering, Los Angeles, CA; M.H. MacDougall and P.D. Dapkus, University of Southern University, Department of Electrical Engineering and Department of Materials Science and Engineering, Los Angeles, CA.

B5.14 PSEUDOMORPHIC GROWTH CONDITIONS FOR ZnSe-BASED II-VI LASERS GROWN ON (001) GaAs SUBSTRATES. L. Zhao, B. Greenberg, E. Snoeks, J. Gaines and Petruzzello, Philips Laboratories, Briarcliff Manor, NY.

B5.15 DIFFUSE SCATTERING FROM STACKING FAULTS ORIGINATING AT THE ZnSe/GaAs INTERFACE. Greg U'Ren, Sandra Lindo, Mark Goorsky, University of California, Los Angeles, Department of Materials Science and Engineering, Los Angeles, CA; Greg-Meis Haugen, K.K. Law and Tom Miller, Science Research Laboratory, St. Paul, MN.

B5.16 THE INFLUENCE OF PRELAYERS ON THE SURFACE MORPHOLOGY OF GaAs FILMS GROWN ON OFFCUT Ge/Si SUBSTRATES. Qin Xu, L.W.P. Hsu, University of Virginia, Department of Physics, Charlottesville, VA; E.A. Fitzgerald, Department of Materials Science and Engineering, MIT, Cambridge, MA; J. Kuo, Y.H. Xie and P.J. Silverman, AT&T Bell Laboratory, Murry Hill, NJ.

B5.17 THE CHANGE OF MICROSTRUCTURES IN SiGe FILM GROWN ON (001) Si SUBSTRATE USING SPE METHOD. Sang-Gi Kim, Sahn Nahm, Sun Jin Yun, Kyoung-Ik Cho, In-Ho Bae, Jae-Jin Lee and Kee-Soo Nam, Electronics and Telecommunications Research Institute, Semiconductor Division, Taejeon, Korea.

B5.18 STUDY OF EPITAXIAL SnGe₂ GROWTH BY SOLID PHASE EPITAXY AND PULSED LASER DEPOSITION. M.E. Taylor, G. He, H.A. Atwater, Thomas J. Watson, California Institute of Technology, Laboratories of Applied Physics, Pasadena, CA; and A. Polman, FOM Institute for Atomic and Molecular Physics, Amsterdam, Netherlands.

B5.19 THERMAL RELAXATION OF STRAINED Si_{1-x}Ge_xC_{1-x} ALLOYS ON Si(001). Sean Sego, Robert J. Culbertson, Arizona State University, Department of Physics and Astronomy, Tempe, AZ; Andy E. Bair and T.L. Alford, Arizona State University, Department of Chemical Bio and Materials Engineering, Tempe, AZ.

B5.20 STRAIN RELAXATION, DEFECT DISTRIBUTION AND SURFACE MORPHOLOGY IN HIGHLY MISMATCHED InGaAs/GaAs HETEROSTRUCTURES. L. Francesio, P. Franzosi, L. Lazzarini, G. Salvati, MASPEC-CNR Institute, Parma, Italy; M.R. Brunzi, G. Padeletti and M.G. Simeone, ICMAT-CNR Institute, Roma, Italy.

B5.21 STABILITY OF EPITAXIALLY STRAINED SEMICONDUCTOR STRIPES. A. Atkinson, Imperial College of Science Technology and Medicine, Department of Materials, London, United Kingdom; S.C. Jain and K. Pinardi, IMEC, Kapeldreef, Leuven, Belgium.

B5.22 InAs/AlSb/GaSb RESONANT INTERBAND TUNNELING DIODES ON GaAs SUBSTRATES. Kumar Shiralaji, Jun Shen, Raymond Tsui, Motorola, PCRL, Tempe, AZ.

B5.23 GROWTH KINETICS OF Si_{1-x}Ge_xC_{1-x} FILMS ON Si(100) WITH

$v \leq 0.05$ AND $T = 450-560^\circ\text{C}$, Harald Jacobsson, Nicole Herbots, Sean Hearne, Joan Xiang and Peihua Ye, Arizona State University, Department of Physics and Astronomy, Tempe, AR.

B5.24 STRAIN RELAXATION OF <111> ORIENTED InGaAs/GaAs SINGLE LAYERS AND MULTIQUANTUM WELL (MQW) STRUCTURES. H. Colson, D. Dunstan, University of Surrey, Physics Department, Surrey, United Kingdom; and P. Kidd, University of Surrey, Department of Materials Science and Engineering, Surrey, United Kingdom.

B5.25 DIRECT EVIDENCE OF THREADING DISLOCATION SUPPRESSION IN GaSb/Si EPILAYER BY USING LOW-TEMPERATURE FROWN GaAs INTERMEDIATE LAYER. Tow-Chong Chong, Cheng-Chiang Phua, Wai-Shing Lau and Leng-Seow Tan, National University of Singapore, Centre for Optoelectronics, Department of Electrical Engineering, Singapore.

B5.26 REDUCTION OF DISLOCATION MOBILITY IN Ge₂Si₃/Si(001). Kerstin Jurkschat, Steve Roberts, University of Oxford, Department of Materials, Oxford, United Kingdom.

B5.27 THE MICROSTRUCTURE AND ELECTRICAL BEHAVIOUR OF AS-GROWN AND ANNEALED HEAVILY C-DOPED GaAs AND InGaAs GROWN BY CHEMICAL BEAM EPITAXY. Simon Westwater, Tim Bullough, Liverpool University, Department of Materials Science, Liverpool, United Kingdom.

B5.28 STRUCTURAL ASPECTS AND ELECTRICAL TRANSPORT PROPERTIES OF THE Si(100)/CoSi/Si HETEROSTRUCTURE. M. Hacke, J. Kim, F. Klinkhammer, M. Dolle, H.L. Bay and S. Mantl, Institut für Schicht-und Ionentechnik, Jülich, Germany.

B5.29 OPTICAL PROPERTIES OF WIRE-LIKE CORRUGATED SURFACE STRUCTURES IN InGaAs LINEAR GRADED BUFFER LAYER GROWN ON GaAs BY MOCVD. B. Lee, J.H. Baek, W.S. Han, S.W. Choi, J.H. Lee and E.H. Lee, Electronics and Telecommunications Research Institute, Taejeon, Korea.

B5.30 DISLOCATION SELF-ANNIHILATION AND STRAIN IN HETEROEPITAXIAL MATERIALS. Ken Durose and Ruth I. Port, University of Durham, Department of Physics, Durham, United Kingdom.

B5.31 IN-SITU LIGHT SCATTERING MEASUREMENT OF SURFACE ROUGHNESS DURING GROWTH OF InGaAs ON GaAs AND InP SUBSTRATES. Tom H. Pinnington, Tom Tiedje, Mario Beaudoin, Bernard Haveman, Christian Lavoie and Ahmad Mohades-Kassai, University of British Columbia, Department of Physics and Astronomy, Vancouver, Canada.

SESSION B6: DEFECTS IN QUANTUM STRUCTURES

Chairs: B.W. Wessels and R.S. Goldman
Wednesday Morning, April 10
Sunset E

8:30 A.M. **B6.1**
STUDIES OF CARRIER TRANSPORT AND RECOMBINATION IN PARTIALLY RELAXED InGaAs/GaAs AND InGaP/GaAs FILMS AND NANOSTRUCTURES USING NOVEL IMAGING EXPERIMENTS. D.H. Rich, University of Southern California, Department of Materials Science and Engineering, Los Angeles, CA.

9:00 A.M. **B6.2**
IMPACT OF MBE GROWTH CONDITIONS ON DEEP-LEVEL STATES AT THE INVERTED GaAs/AlAs INTERFACE. P. Krispin and R. Hey, Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany.

9:15 A.M. **B6.3**
OPTICAL ANALYSIS OF THE INTERFACE PROPERTIES OF InAs/InP HETEROSTRUCTURES GROWN BY CBE. J. Geurts, Aachen University of Technology, I. Physikalisches RWTH, Aachen, Germany; J. Hermans, M. Pohlmann, I. Physikalisches Institut der RWTH, Aachen, Germany; R. Rongen, M. Leys, and J. Wolter, Eindhoven University of Technology, Department of Physics, Eindhoven, Netherlands.

9:30 A.M. **B6.4**
OPTICAL CHARACTERIZATION OF AlInGaAs/InGaAs QUANTUM WELL STRUCTURES ON InGaAs SUBSTRATES. L. Jedral, C. Edirisinghe, H. Ruda, University of Toronto, Department of Metallurgy and Materials Science, Toronto, Canada; A. Moore, Optoelectronics Division, EG&G Canada Ltd., Vaudreuil, Canada; and B. Lent, Crystar Research Inc., Victoria, Canada.

9:45 A.M. **B6.5**
INFLUENCE OF MISFIT DISLOCATIONS ON CARRIER RECOMBINATION AND CURRENT GAIN IN InGaAs/GaAs HETEROJUNCTION PHOTOTRANSISTORS. H.T. Lin, D.H. Rich, University of Southern California, Department of Materials Science and Engineering, Los Angeles, CA; O. Sjölund, M. Ghisoni and A. Larsson, Chalmers University of Technology, Department of Optoelectronics and Electrical Measurements, Göteborg, Sweden.

10:00 A.M. BREAK

10:30 A.M. **B6.6**

THE GROWTH OF HIGH QUALITY InGaAs QUANTUM WELLS ON GaAs (111)A SUBSTRATES, Michael R. Fahy, Interdisciplinary Research Centre for Semiconductor Materials, London, United Kingdom and ATR Optical and Radio Communication Laboratories, Kyoto, Japan; Kazuhisa Fujita, Mitsuo Takahashi, Pablo O. Vaccaro and Toshihide Watanabe, ATR Optical and Radio Communication Laboratories, Kyoto, Japan.

10:45 A.M. **B6.7** *Withdrawn*

INFLUENCE OF PHASE TRANSITIONS ON THE OPTICAL AND ELECTRICAL PROPERTIES OF EXPTAXIAL InGaAs/InP HETEROSTRUCTURES, A.I. Belogorokhov, A.F. Orlov, A.N. Osipova, E.V. Solov'eva, State Institute of Rare Metals, Moscow, Russia.

11:00 A.M. **B6.8**

DISLOCATION REDUCTION OF PLANAR AND SELECTIVELY GROWN GaAs LAYERS ON Si SUBSTRATES, K. Ziegler, G. Hahn, J.S. Im, A. Hangleiter, D. Haase, A. Dörnen, Universität Stuttgart, 4 Physikalisches Institut, Stuttgart, Germany; F. Philipp, MPI für Metallforschung, Stuttgart, Germany; and F. Scholz, Universität Stuttgart, 4 Physikalisches Institut, Stuttgart, Germany.

11:15 A.M. **B6.9**

MISMATCH-DRIVEN GROWTH OF InP/GaAs NANO-STRUCTURES: EXPERIMENT AND MODELIZATION, M. Berti, A.V. Drigo and A. Giuliani, Padova University, INFN, Department of Physics, Padova, Italy; M. Mazzer, Imperial College, Department of Materials, London, United Kingdom; G. Rossetto, G. Torzo, ICTIMA-CNR Institute, Padova, Italy; and G. Salvati, MASPEC-CNR Institute, Parma, Italy.

11:30 A.M. **B6.10**

IMAGING INTERFACES OF GaAs/InGaAs BY BALLISTIC-ELECTRON-EMISSION MICROSCOPY, (BEEM), E.Y. Lee, S. Bhargava, R. Mirin, K. Luo, M.A. Chin and V. Narayanamurti, University of California, College of Engineering, Santa Barbara, CA.

11:45 A.M. **B6.11**

MICROANALYTICAL CHARACTERIZATION OF HETEROSTRUCTURES OF ZnSe QUANTUM DOTS SEQUESTERED IN A SILICATE GLASS, Valerie J. Leppert, Subhash H. Risbud, University of California, Division of Materials Science and Engineering, Davis, CA; and Mark J. Fendorf, National Center for Electron Microscopy, Berkeley National Laboratory, Berkeley, CA.

SESSION B7: DEFECTS IN ZnSe - BASED HETEROSTRUCTURES

Chairs: L.J. Brilissen and Z. Liliental-Weber

Wednesday Afternoon, April 10

Sunset E

1:30 P.M. ***B7.1**

CONTROL OF DEFECTS IN ZnSe BASED BLUE/GREEN LASER DIODES, R.L. Gunshor, J. Han, G.C. Hua, Purdue University, West Lafayette, IN; and A.V. Nurmikko, Brown University, Providence, RI.

2:00 P.M. **B7.2**

HETEROEPITAXIAL GROWTH OF WIDE BANDGAP II-VI ALLOYS ON InP SUBSTRATES, M. Tamargo, C. Cavus, L. Zeng, B. Yang, City College of New York, Chemistry Department, New York, NY; F. Semendy, A. Gray, N. Bambha, Army Research Laboratory, Ft. Belvoir, VA; E. Snoeks and I. Zhao, Philips Laboratories, Briarcliff Manor, NY.

2:15 P.M. **B7.3**

STRUCTURAL CHARACTERIZATION OF LATTICE MATCHED ZnCdSe LAYERS GROWN BY MBE ON InP SUBSTRATES, E. Snoeks, L. Zhao and J. Petruzzello, Philips Laboratories, Briarcliff Manor, NY; A. Cavus, L. Zeng, B. Yang and M.C. Tamargo, City College of CUNY, Department of Chemistry, New York, NY.

2:30 P.M. **B7.4**

DEPENDENCE OF GENERATION AND STRUCTURE OF SHOCKLEY-TYPE STACKING FAULTS ON VI/II FLUX RATIO IN ZnSe/GaAs, L.H. Kuo, K. Kimura, S. Miwa, T. Yasuda, C. Jin, K. Tanaka and T. Yao, Joint Research Center for Atom Technology, Ibaraki, Japan.

2:45 P.M. **BREAK**

3:15 P.M. ***B7.5**

GROWN-IN DEFECTS THAT GIVE RISE TO DARK LINE DEFECTS IN BLUE II-VI SEMICONDUCTOR DIODE LASER, L. Salamanca-Riba, University of Maryland, Department of Materials and Nuclear Engineering, College Park, MD.

3:45 P.M. **B7.6**

ACTIVATION ENERGY OF NONRADIATIVE PROCESSES IN DEGRADED II-VI LASER DIODES GROWN BY MBE, L.-L. Chao, G.S. Cargill III, C. Kothandaraman, Columbia University, New York, NY; T. Marshall, M. Buijs and J. Petruzzello, Philips Laboratories, Philips Electronics North America Corporation, Briarcliff Manor, NY.

4:00 P.M. **B7.7**

QUANTITATIVE ANALYSIS OF THE DEFECT DENSITY AT ZnSe-GaAs INTERFACES BY RAMAN SPECTROSCOPY, J. Geurts, Aachen University of Technology, I. Physikalisches Institut RWTH, Aachen, Germany; J. Hermans, I. Physikalisches Institut der RWTH, Aachen, Germany; J. Söllner, Institut für Halbleitertechnik, Aachen, Germany; and M. Heuken, Institut für Halbleitertechnik, Aachen, Germany.

4:15 P.M. **B7.8**

DARK LINE DEFECTS IN II-VI ZnSe BASED SINGLE QW LIGHT EMITTING DIODES, J.R. Kim, K.S. Jones, V. Krishnamoorthy, University of Florida, Department of Materials Science and Engineering, Gainesville, FL; and P.S. Zory Jr., University of Florida, Department of Electrical Engineering, Gainesville, FL.

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